Radio Telemetry Studies of Adult Shortnose and Lost River Suckers in Upper Klamath Lake and Tributaries, Oregon 1993 - 1999

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Introduction

The U.S. Bureau of Reclamation conducted radio telemetry studies of adult shortnose (*Chasmistes brevirostris*) and Lost River (*Deltistes luxatus*) suckers on Upper Klamath and Agency Lakes and tributaries from 1993 to 1999. Study objectives included monitoring temporal and spatial distribution patterns, spawning timing and duration, location of summer refugial areas, and relation of sucker distribution to water quality. Suckers were captured and tagged from several areas, including Sucker Springs, Williamson and Wood rivers, and other areas throughout Upper Klamath and Agency lakes. These locations encompass all of the major sucker spawning areas and some non spawning areas throughout the lake. This report is intended to provide a brief summary of the sucker radio telemetry study. An additional analysis will be included in the biological assessment.

Methods

Suckers were captured using trammel nets during the late winter, spring and early summer, during periods of relatively good water quality conditions. Radio tags were surgically implanted using anesthesia and sterile techniques that minimized trauma to the fish. Attempts to locate the tagged fish were made by fixed wing aircraft on a monthly basis in winter, and weekly by aircraft and boat in spring, summer and fall. Upon locating a fish by boat, coordinates were obtained with a geographical positioning system (GPS) unit (accuracy 3-100 m depending on unit). Additionally, water quality, algal density, bottom substrate class and bottom depth data were recorded. Water quality parameters were measured at 0.5 m from the surface, 1.0 m from surface, 0.2 m from bottom, and if the bottom depth was greater than or equal to 3. 0 m, a sample was taken at the mid depth. Water temperature, dissolved oxygen, specific conductance and pH were measured with a calibrated Hydrolab multi-parameter instrument. Air temperature, wind direction and wind speed were also recorded. Detailed methods and metadata are not included but are available upon request.

Results/Discussion

A total of 33 Lost River suckers and 43 shortnose suckers were tagged from 1993-1999 (Table 1). Eighteen female, 15 male Lost River suckers, and 27 female, 15 male and one unknown sex shortnose sucker were tagged throughout the study period. Suckers (both species) were tagged in 10 locations throughout Upper Klamath Lake and tributaries.

Upper Klamath Lake, Agency Lake, and tributaries (referred to hereon as Upper Klamath Lake) were divided into 16 areas based on the following four criteria: tributaries, tributary influence, deep water trench and broader scale lake delineations (Figure 1). The Wood and Williamson Rivers and Pelican Bay are tributaries to Upper Klamath and Agency Lakes. Upper Agency Lake, Offshore Pelican Bay, Offshore Williamson River, and East Shore Springs are areas of tributary influence. Deep water trenches (areas greater than 3m deep) include Ball Point Trench and Eagle Ridge Trench. Large scale lake delineations include Lower Agency Lake, Mid North, Ball Bay, Shoalwater Bay, Mid Lake, Wocus Bay, and Lower Lake. The 16 areas were developed to help summarize sucker movements throughout Upper Klamath Lake over time.

Table 2 summarizes all sucker locations from May 1993 to September 1999. Suckers that died within one month of tag date were not included. The November to February time period was grouped together because this period includes good water quality, relatively little spawning activity, and wide distribution of suckers.

Most suckers spawn in tributaries and springs to Upper Klamath Lake from March to early June, depending on location and species. Poor water quality, bacterial growth, and parasites from July through September can become stressful or lethal to suckers in Upper Klamath Lake. During periods of poor water quality conditions, suckers move towards areas of relatively good water quality including tributaries and areas of tributary influence. Conditions improve in October allowing suckers to disperse throughout the lake.

The total number of locations (Table 2, bottom row) for each species by month changes over time due to additional suckers being implanted with radio tags, radio tagged suckers dying, tag failure, differing search effort, and success/failure of locating radio tagged fish.

Tables 3-8 summarize sucker locations by year from 1993 to 1998. Suckers tagged in the Wood River and Agency Lake were not included, as these fish typically remained in Agency Lake which has conditions that are not directly comparable to conditions found in Upper Klamath Lake. All suckers tagged during 1999 were from Agency Lake and therefore all 1999 data was eliminated from Tables 3-8. However, several Upper Klamath Lake suckers moved into Agency Lake (Lower and Upper), therefore these areas remain in the tables. No Upper Klamath Lake suckers moved into the Wood River, therefore this area was deleted, reducing the total number of areas to 15. Suckers that died within one month of tag date were not included.

Box and whisker plots of water depth and water quality parameters where radio tagged fish were located were generated using SPSS statistical software (Figures 2-9). Water quality data from the bottom was used because it is assumed that adult suckers are normally located there. Depth sensing tags used in 1997 and 1998 generally confirmed this assumption.

These summary plots show the median, quartiles, outliers, and extreme values. The box represents the interquartile range which contains 50% of values. A horizontal line across the box indicates the median. The whiskers are lines that extend from the box to the highest and lowest

values, excluding outliers and extremes. Outliers are indicated by a plus (+) and represent values that are between 1.5 and 3 box lengths from either end of the box. Extreme values are indicated by a dot (.) and represent values that are greater than 3 box lengths from either end of the box. Abbreviations include: LRS= Lost River sucker, SNS= shortnose sucker, and n= sample size.

Figures 2-5 summarize bottom water quality measurements where radio tagged suckers were located from June through October, by year, and by species.

Median bottom depths for both species ranged from 1.7 - 2.8 m from 1993 to 1998 (Figure 2). The shallowest median (1.7 m) and minimum (0.4 m) bottom depths occurred in 1994 which is the only drought year represented in these plots. Upper Klamath Lake reached a minimum elevation of 4,136.8 ft on October 4, 1994, compared to minimum elevations of 4,139.3, 4,138.6, 4,138.7, 4,140.1, and 4,139.9 ft for 1993, 1995, 1996, 1997, and 1998 respectively. Shortnose suckers occurred at shallower median depths than Lost River suckers for all years except 1993 and 1998 and at shallower minimum depths for all years except 1997 and 1998.

Median bottom dissolved oxygen (DO) values for both species ranged from 6.5 - 7.9 mg/L, while fifty percent of all DO values exceeded 5.0 mg/L from 1993 to 1998 (Figure 3). These DO values are suitable for both species of suckers, however, all measurements were taken during daylight hours, presumably during hours of higher DO values.

Median bottom pH values for both species ranged from 8.45 - 9.40 units, while fifty percent of all pH values ranged from 7.75 - 9.55 units (Figure 4). The highest median and maximum pH values occurred in 1995, the first recent year that a large scale fish kill occurred on Upper Klamath Lake.

Median bottom water temperature for both species ranged from 17.2 - 19.0 C, while fifty percent of all temperature values ranged from 14.5 - 21.0 C (Figure 5). Bottom water temperatures was similar between species and between years.

Besides depth, there were no consistent differences between species for any parameter (dissolved oxygen, pH, temperature). This indicates that both species occupied areas with similar water quality conditions.

Water quality in the eight weeks prior to a radio tagged suckers death was plotted to determine if certain parameters may have contributed to the fishes death (Figures 6-9). Although suckers that died within one month of tag date or within one month of being located in a river (spawning related) were excluded, it is difficult to determine the exact cause of death. Possible reasons include: complications from surgery, poor water quality conditions, parasites, spawning stress, or a combination of these.

Figure 6 shows the bottom depth at which dying suckers were located. Median values ranged from 1.8 - 2.8 m, with the lowest median value occurring on the confirmed date of death (mort date). Also, there is a general decrease in depth as mort date approaches. Sick and dying suckers have been noted to move towards areas of tributary influence, mainly Pelican Bay. The area offshore of Pelican Bay is shallower than other portions of Upper Klamath Lake where many suckers seek refuge in the summertime.

Median bottom DO in the eight weeks prior to a sucker dying ranged from 6.5 - 8.2 mg/L, while fifty percent of all DO values ranged from 3.8 - 9.8 mg/L (Figure 7). Minimum values of

less than 1.0 mg/L occurred at mort2week and on the mort date, while the minimum DO value on mort1week was 5.4 mg/L.

Median bottom pH values ranged from 8.95 - 9.35 units, while fifty percent of all pH values ranged from 8.40 - 9.50 units (Figure 8). The lowest median and fifty percentile occurred on the mort date, representing suckers that had moved towards Pelican Bay before dying.

Median bottom water temperature values ranged from 18.8 - 19.6 C, while fifty percent of all temperature values ranged from 16.9 - 22.3 C (Figure 9).

None of these parameters, looked at individually, denotes a clear explanation for sucker mortality. Lethal minimum values of DO may be a major cause for a few of the sucker deaths, however a combination of stressful levels of one or more water quality parameters, including ammonia, along with infection and parasites, is most likely the cause of death of most of these suckers.

The ArcView-generated sucker distribution maps (attached) show monthly summaries of fish locations but do not include mort date locations. However, the individual fish distribution maps do include the mort date.

Acknowledgments

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Table 1. Lost River and shortnose suckers tagged in Upper Klamath Lake and tributaries from 1993-1999.

FishID	Frequency	Species	Sex	Length	Weight	TagLocation	TagDate	MortDate	TagFailDate
A	164.435	Lost River Sucker	Female	743		Sucker Spring	22-Apr-93	02-Jun-93	
D	164.516	Lost River Sucker	Male	491	1430	Sucker Spring	22-Apr-93		27-Oct-94
E	164.536	Lost River Sucker	Male	625	3074	Sucker Spring	22-Apr-93	24-Aug-93	
F	164.563	Shortnose Sucker	Female	469	1550	Sucker Spring	22-Apr-93		31-Aug-95
C	164.485	Lost River Sucker	Male	685	3628	Sucker Spring	26-Apr-93		10-Oct-96
G	164.585	Lost River Sucker	Female	734	4610	Sucker Spring	26-Apr-93		03-May-95
L	164.717	Lost River Sucker	Female	731	4840	Sucker Spring	26-Apr-93	27-Sep-93	
K	164.683	Lost River Sucker	Male	604		Williamson River	18-May-93		11-Apr-96
H	164.615	Shortnose Sucker	Female	468		Williamson River	18-May-93	16-Jun-93	
I	164.633	Lost River Sucker	Male	617	2388	Williamson River	20-May-93	23-Oct-96	
J	164.665	Shortnose Sucker	Female	440		Williamson River	20-May-93	16-Jun-93	
B	164.465	Shortnose Sucker	Male	505		Ball Pt.	11-Jun-93	30-Jun-93	
R	164.895	Lost River Sucker	Female	612	3214	Williamson River mouth	22-Mar-94		22-Jun-94
S	164.925	Lost River Sucker	Female	760	4680	Williamson River mouth	22-Mar-94		21-Sep-94
M	164.735	Shortnose Sucker	Male	455	1660	Williamson River mouth	24-Mar-94	03-Aug-95	
N	164.757	Shortnose Sucker	Female	520	2520	Williamson River mouth	25-Mar-94	26-May-94	
O	164.786	Shortnose Sucker	Male	530	2112	Williamson River mouth	25-Mar-94	21-Jul-94	
P	164.825	Lost River Sucker	Male	524	1633	Williamson River mouth	13-Apr-94		03-May-95
Q	164.856	Lost River Sucker	Male	608	2890	Sucker Spring	13-Apr-94		13-Jul-95
U	164.955	Lost River Sucker	Male	619	3376	Sucker Spring	13-Apr-94	20-Jul-94	
J1	164.665	Lost River Sucker	Female	536	1940	Sucker Spring	28-Apr-94	03-Oct-96	
A1	164.435	Shortnose Sucker	Female	420	1470	Ball Pt.	28-Apr-94		07-Nov-95
H1	164.623	Lost River Sucker	Female	424	870	Ball Pt.	24-May-94	13-Jul-95	
K1	164.715	Shortnose Sucker	Female	384	820	Williamson River mouth	24-May-94	22-Jun-94	
I1	164.674	Shortnose Sucker	Female	410	980	Ball Pt.	25-May-94	03-Aug-94	
M2	164.193	Lost River Sucker	Male	482	1302	Williamson River mouth	28-Mar-95	20-Sep-95	
B2	164.023	Shortnose Sucker	Female	460	1900	Williamson River mouth	28-Mar-95	28-Jun-95	
E2	164.110	Shortnose Sucker	Male	414	1180	Williamson River mouth	28-Mar-95		06-May-96
G2	164.133	Shortnose Sucker	Male	412	1136	Williamson River mouth	28-Mar-95	17-May-95	
I2	164.154	Shortnose Sucker	Male	425	1031	Williamson River mouth	28-Mar-95		26-Jun-96
K3	164.173	Shortnose Sucker	Male	408	957	Williamson River mouth	28-Mar-95		11-Apr-96
N2	164.203	Shortnose Sucker	Female	484	1870	Williamson River mouth	28-Mar-95	30-Apr-96	
A2	164.013	Shortnose Sucker	Female	360	786	Williamson River mouth	03-Apr-95	24-Aug-95	
C2	164.035	Shortnose Sucker	Male	402	926	Williamson River mouth	03-Apr-95		08-Aug-96
D2	164.103	Shortnose Sucker	Male	422	1007	Williamson River mouth	03-Apr-95		24-Jul-96
F2	164.124	Shortnose Sucker	Female	432	1174	Williamson River mouth	03-Apr-95	10-Oct-95	
H2	164.143	Shortnose Sucker	Male	398	906	Williamson River mouth	03-Apr-95	08-Jun-95	
J2	164.163	Shortnose Sucker	Male	440	1162	Williamson River mouth	03-Apr-95	01-Jun-95	
L2	164.184	Shortnose Sucker	Female	456	1343	Williamson River mouth	03-Apr-95		16-Jul-96
C6	164.233	Shortnose Sucker	Female	436	1305	Agency Lake/Wood River mouth	14-Mar-96	15-Mar-96	
I6	164.293	Shortnose Sucker	Female	504	2666	Agency Lake/Wood River mouth	15-Mar-96		15-Jul-98
J6	164.304	Shortnose Sucker	Female	456	1630	Agency Lake/Wood River mouth	26-Mar-96	25-Jun-97	
K6	164.313	Shortnose Sucker	Female	522	2470	Agency Lake/Wood River mouth	26-Mar-96		08-Apr-97
L6	164.322	Shortnose Sucker	Female	532	2785	Agency Lake/Wood River mouth	26-Mar-96	16-May-96	
B6	164.223	Shortnose Sucker	Male	476	1558	Agency Lake/Wood River mouth	09-Apr-96	28-Aug-96	
D6	164.244	Lost River Sucker	Female	494	1470	Agency Lake/Wood River mouth	26-Apr-96	29-May-97	
M6	164.335	Lost River Sucker	Female	527	2248	Chiloquin Dam Fish Ladder	09-May-96	05-Mar-97	
E6	164.254	Shortnose Sucker	Female	420	1140	Chiloquin Dam Fish Ladder	09-May-96	11-Sep-96	
G6	164.273	Shortnose Sucker	Female	432	1196	Wood River	17-May-96		08-Aug-97
F6	164.263	Shortnose Sucker	Male	422	960	Wood River	17-May-96	02-Jul-96	

Table 1(continued). Lost River and shortnose suckers tagged in Upper Klamath Lake and tributaries from 1993-1999.

FishID	Frequency	Species	Sex	Length	Weight	TagLocation	TagDate	MortDate	TagFailDate
A7	165.134	Shortnose Sucker	Female	410	958	Government Hill area (UKL)	07-May-97	08-Aug-97	
B7	165.145	Lost River Sucker	Male	500	1532	Government Hill area (UKL)	07-May-97	30-Jul-97	
C7	165.155	Shortnose Sucker	Female	418	1070	Government Hill area (UKL)	07-May-97	25-Jun-97	
D7	165.163	Shortnose Sucker	Female	420	1188	Government Hill area (UKL)	07-May-97	03-Jun-99	
E7	165.176	Shortnose Sucker	Female	406	802	Government Hill area (UKL)	13-May-97	15-May-97	
F7	165.184	Lost River Sucker	Male	466	1100	Government Hill area (UKL)	13-May-97	11-Jun-97	
G7	165.194	Lost River Sucker	Female	518		Government Hill area (UKL)	30-May-97	30-May-97	
H7	165.204	Lost River Sucker	Male	466		Government Hill area (UKL)	30-May-97	02-Jul-97	
I7	165.213	Lost River Sucker	Female	479		Government Hill area (UKL)	30-May-97	21-Aug-97	
J7	165.224	Lost River Sucker	Female	495		Government Hill area (UKL)	30-May-97	14-Aug-97	
K7	165.233	Lost River Sucker	Male	538	1797	Ball Pt.	11-Jul-97	30-Jul-97	
L7	165.242	Lost River Sucker	Female	496	1236	Ball Pt.	11-Jul-97	02-Sep-98	
M7	165.256	Lost River Sucker	Male	448	996	Ball Pt.	11-Jul-97	24-Jul-97	
T7	165.184	Lost River Sucker	Female	545	1094	Ball Pt.	11-Jul-97	18-Jul-97	
B8	165.384	Lost River Sucker	Female	480	1145	Skillet Handle	27-Mar-98	22-Jul-98	
G8	165.305	Lost River Sucker	Female	570	2109	Link River Dam Fish Ladder	15-Jun-98	15-Jun-98	
I8	164.906	Lost River Sucker	Female	720	3950	Ball Pt.	16-Jun-98	16-Sep-98	
J8	164.877	Lost River Sucker	Female	568	1716	Ball Pt.	16-Jun-98		30-Dec-98
K8	164.643	Lost River Sucker	Male	579	2085	Ball Pt.	16-Jun-98		03-Nov-98
Q9	165.113	Shortnose Sucker			3590	Agency Lake/Wood River mouth	05-May-99		24-May-99
R9	164.424	Shortnose Sucker	Female	560	2910	Agency Lake/Wood River mouth	05-May-99	24-Jun-99	
S9	164.454	Shortnose Sucker	Female	525	2520	Agency Lake/Wood River mouth	05-May-99		05-Aug-99
T9	165.123	Shortnose Sucker	Male	445	1514	Agency Lake/Wood River mouth	05-May-99	24-Jun-99	
AA9	164.634	Shortnose Sucker	Female	541	2280	Agency Lake/Wood River mouth	19-May-99		21-Sep-99
BB9	164.813	Shortnose Sucker	Male	476	1508	Agency Lake/Wood River mouth	19-May-99		05-Aug-99
Z9	164.726	Shortnose Sucker	Female	509	2278	Agency Lake/Wood River mouth	19-May-99		05-Aug-99

Figure 1. Location names for Upper Klamath and Agency Lakes and tributaries used for summarizing sucker radio telemetry data.

Table 2. Number and percent of suckers present in 16 locations from Upper Klamath and Agency Lakes and tributaries, 1993-1999 (SNS=shortnose, LRS=Lost River).

1993-1999	Nov.-Feb.		March		April		May		June		July		August		September		October	
Location	SNS(%)	LRS(%)	SNS(%)	LRS(%)	SNS(%)	LRS(%)	SNS(%)	LRS(%)	SNS(%)	LRS(%)	SNS(%)	LRS(%)	SNS(%)	LRS(%)	SNS(%)	LRS(%)	SNS(%)	LRS(%)
Wood River					5(7)		23(16)		4(3)									
Upper Agency Lake	14(21)		9(24)		18(25)		21(15)		24(18)		25(21)		14(14)		6(8)		3(6)	
Lower Agency Lake	5(8)		3(8)		4(5)		6(4)	1(2)	9(7)		1(1)				6(8)		9(18)	
Pelican Bay											1(1)							
Offshore Pelican Bay	1(2)	4(6)					2(1)	6(10)	12(9)	32(33)	25(21)	59(53)	33(32)	55(41)	8(10)	16(16)	2(4)	8(11)
Mid North	3(5)	16(23)	2(5)	5(18)		1(3)	17(12)	4(6)	17(13)	9(9)	30(26)	29(26)	32(31)	57(43)	19(25)	33(33)	3(6)	14(19)
Ball Point Trench	4(6)	3(4)				2(5)	1(1)	1(2)	2(1)	6(6)	5(4)	7(6)	7(7)	4(3)	2(3)	15(15)	3(6)	10(13)
Ball Bay	6(9)	2(3)		1(4)	1(1)	4(11)	14(10)	8(13)	20(15)	16(16)	18(15)	3(3)	3(3)	7(5)	18(23)	6(6)	24(47)	5(7)
Shoalwater Bay			3(8)	1(4)	7(10)	4(11)	21(15)	25(40)	16(12)	23(23)		2(2)			2(3)			
Williamson River			1(3)		30(41)	6(16)	7(5)	11(18)					1(1)					
Offshore Williamson R.	19(29)	27(39)	13(35)	11(39)	4(5)	6(16)	18(13)	1(2)	10(7)	2(2)	8(7)	6(5)	10(10)	5(4)	9(12)	13(13)	5(10)	14(19)
Eagle Ridge Trench	2(3)	1(1)		2(7)		1(3)	4(3)		13(10)	5(5)	2(2)	2(2)	2(2)	2(2)		2(2)		4(5)
Mid Lake	12(18)	16(23)	4(11)	4(14)	2(3)	3(8)	1(1)		6(4)	1(1)	2(2)			3(2)	4(5)	13(13)	2(4)	18(24)
East Shore Spring		1(1)	2(5)	2(7)	2(3)	10(27)		1(2)							2(3)			
Wocus Bay							3(2)	1(2)	1(1)	3(3)		1(1)			1(1)			
Lower Lake				2(7)			6(4)	3(5)		1(1)		2(2)				1(1)		2(3)
Total	**66**	**70**	**37**	**28**	**73**	**37**	**144**	**62**	**134**	**98**	**117**	**111**	**102**	**133**	**77**	**99**	**51**	**75**

Table 3 - 8. Number of suckers present in 15 locations from Upper Klamath and Agency Lakes and tributaries, 1993-1998 (SNS=shortnose, LRS=Lost River).

Table 3.

1993	Nov.-Feb.		March		April		May		June		July		August		September		October	
Location	**SNS**	**LRS**	**SNS**	**LRS**	**SNS**	**LRS**	**SNS**	**LRS**	**SNS**	**LRS**	**SNS**	**LRS**	**SNS**	**LRS**	**SNS**	**LRS**	**SNS**	**LRS**
Upper Agency Lake																		
Lower Agency Lake																		
Pelican Bay																		
Offshore Pelican Bay		1								2	1	7		13		4		
Mid North		1							1		1	5		6	1	6		3
Ball Point Trench												1	1			1		6
Ball Bay	1	1							1	2	1		1	1			3	1
Shoalwater Bay							1	3	5	12								
Williamson River																		
Offshore Williamson R.		2																3
Eagle Ridge Trench																		
Mid Lake	1	5																2
East Shore Spring																		
Wocus Bay																		
Lower Lake																		
Total	2	10	0	0	0	0	1	3	7	16	3	13	2	20	1	11	3	15

Table 4.

1994	Nov.-Feb.		March		April		May		June		July		August		September		October	
Location	**SNS**	**LRS**	**SNS**	**LRS**	**SNS**	**LRS**	**SNS**	**LRS**	**SNS**	**LRS**	**SNS**	**LRS**	**SNS**	**LRS**	**SNS**	**LRS**	**SNS**	**LRS**
Upper Agency Lake																		
Lower Agency Lake																		
Pelican Bay																		
Offshore Pelican Bay		1							2	6	4	11	3	20	4	2		
Mid North	1	7	1	2			1			3	1	4	3	23	4	12	2	3
Ball Point Trench							1			2				2		7	2	
Ball Bay					1		1	3	4	5				6	11	2	3	2
Shoalwater Bay				1	2	3		7	2	5								
Williamson River			1		4	4												
Offshore Williamson R.	3	10	1	6	1	5		1	1		2		4	2	4	6	1	6
Eagle Ridge Trench							1		1									
Mid Lake				2		1								1		12	2	16
East Shore Spring			1			7												
Wocus Bay																		
Lower Lake																		2
Total	4	18	4	11	8	20	4	11	10	21	7	15	10	54	23	41	10	29

Table 5. 1995	Nov.-Feb.		March		April		May		June		July		August		September		October	
Location	**SNS**	**LRS**	**SNS**	**LRS**	**SNS**	**LRS**	**SNS**	**LRS**	**SNS**	**LRS**	**SNS**	**LRS**	**SNS**	**LRS**	**SNS**	**LRS**	**SNS**	**LRS**
Upper Agency Lake																		
Lower Agency Lake																		
Pelican Bay																		
Offshore Pelican Bay	**1**	**1**					**2**	**2**	**7**	**7**	**11**	**14**	**27**	**14**	**3**	**3**		**3**
Mid North	**2**	**4**	**1**	**1**			**10**	**3**	**9**	**3**	**9**	**1**	**21**	**9**	**14**	**8**	**1**	**3**
Ball Point Trench	**3**	**1**				**1**			**2**	**3**	**3**	**3**	**4**	**1**	**1**		**2**	
Ball Bay	**5**						**7**	**1**	**2**		**8**				**2**		**11**	
Shoalwater Bay			**2**		**3**	**1**	**18**	**4**	**8**	**1**					**1**			
Williamson River					**9**		**5**	**8**										
Offshore Williamson R.	**3**	**7**	**1**	**3**	**2**	**1**	**13**		**5**		**4**			**1**		**2**		
Eagle Ridge Trench	**1**								**2**				**1**					
Mid Lake	**1**	**3**		**1**	**2**		**1**		**1**						**2**			
East Shore Spring				**2**		**1**		**1**							**1**			
Wocus Bay							**2**											
Lower Lake				**2**			**1**									**1**		
Total	**16**	**16**	**4**	**9**	**16**	**4**	**59**	**19**	**36**	**14**	**35**	**18**	**53**	**25**	**24**	**14**	**14**	**6**

Table 6. 1996

	Nov.-Feb.		March		April		May		June		July		August		September		October	
Location	SNS	LRS	SNS	LRS	SNS	LRS	SNS	LRS	SNS	LRS	SNS	LRS	SNS	LRS	SNS	LRS	SNS	LRS
Upper Agency Lake																		
Lower Agency Lake																		
Pelican Bay																		
Offshore Pelican Bay								3		10	1	9		4		5		4
Mid North		3		2					2		6	7	2	8		1		1
Ball Point Trench	1	1				1					1	1				1		1
Ball Bay		1				2	1	1		2			1		1	4		1
Shoalwater Bay					2		2	5		4		1						
Williamson River					29	2	1	3										
Offshore Williamson R.	8	4	11	2	1		4				1	1	1	2		3		1
Eagle Ridge Trench	1								4		1		1					
Mid Lake	7	3	3	1		1			5					1				
East Shore Spring		1	1		2	3												
Wocus Bay									1									
Lower Lake							1											
Total	17	13	15	5	34	9	9	12	12	16	10	19	5	15	1	14	0	8

Table 7. 1997

	Nov.-Feb.		March		April		May		June		July		August		September		October	
Location	SNS	LRS	SNS	LRS	SNS	LRS	SNS	LRS	SNS	LRS	SNS	LRS	SNS	LRS	SNS	LRS	SNS	LRS
Upper Agency Lake	1																	
Lower Agency Lake	1							1									2	
Pelican Bay																		
Offshore Pelican Bay										4	2	9		2		1		
Mid North								1	1	3	4	7		4				
Ball Point Trench		1														2		
Ball Bay									1	2	1							1
Shoalwater Bay								1		1								
Williamson River							1						1					
Offshore Williamson R.									1	2		1	1		1			1
Eagle Ridge Trench							3		6		1							
Mid Lake		2							1	2	1				1			
East Shore Spring																		
Wocus Bay							1								1			
Lower Lake								2										
Total	2	3	0	0	0	0	5	5	10	14	9	17	2	6	3	3	2	2

Table 8.

1998	Nov.-Feb.		March		April		May		June		July		August		September		October	
Location	SNS	LRS	SNS	LRS	SNS	LRS	SNS	LRS	SNS	LRS	SNS	LRS	SNS	LRS	SNS	LRS	SNS	LRS
Upper Agency Lake																		
Lower Agency Lake	2		1		2		1											
Pelican Bay																		
Offshore Pelican Bay										3		8		2		2		
Mid North		2									2	2		7		7		3
Ball Point Trench				1				1		1		1				1		
Ball Bay						2	3	3	3	5	3	3						
Shoalwater Bay									1									
Williamson River																		
Offshore Williamson R.	3	4										3	4		4	2	4	3
Eagle Ridge Trench																		
Mid Lake																		
East Shore Spring															1			
Wocus Bay								1		3		1						
Lower Lake							4	1		1		2						
Total	5	6	1	1	2	2	8	6	4	13	5	20	4	9	5	12	4	6

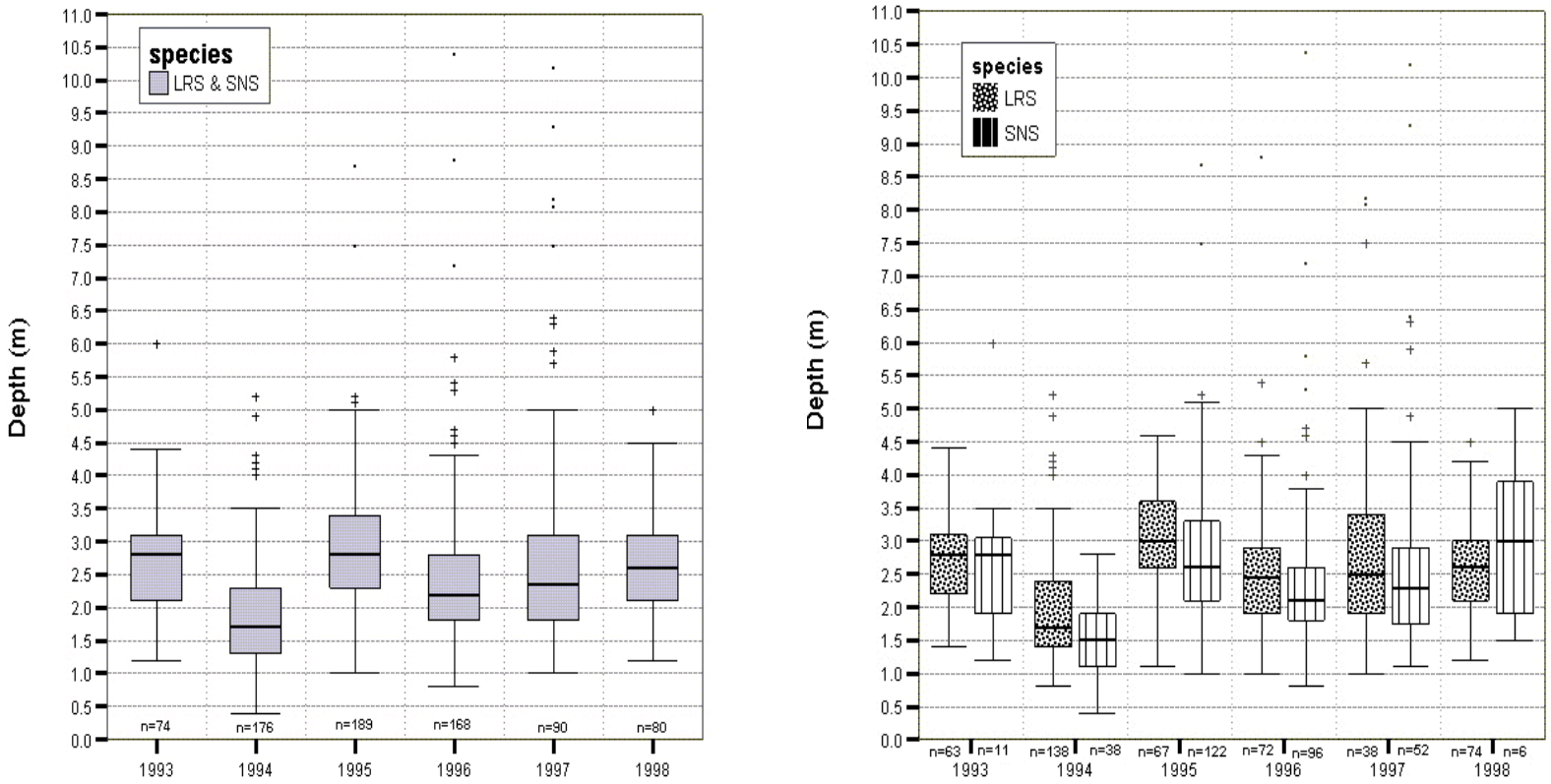


Figure 2. Bottom depth at sites where radio tagged suckers were located, Upper Klamath and Agency Lakes.

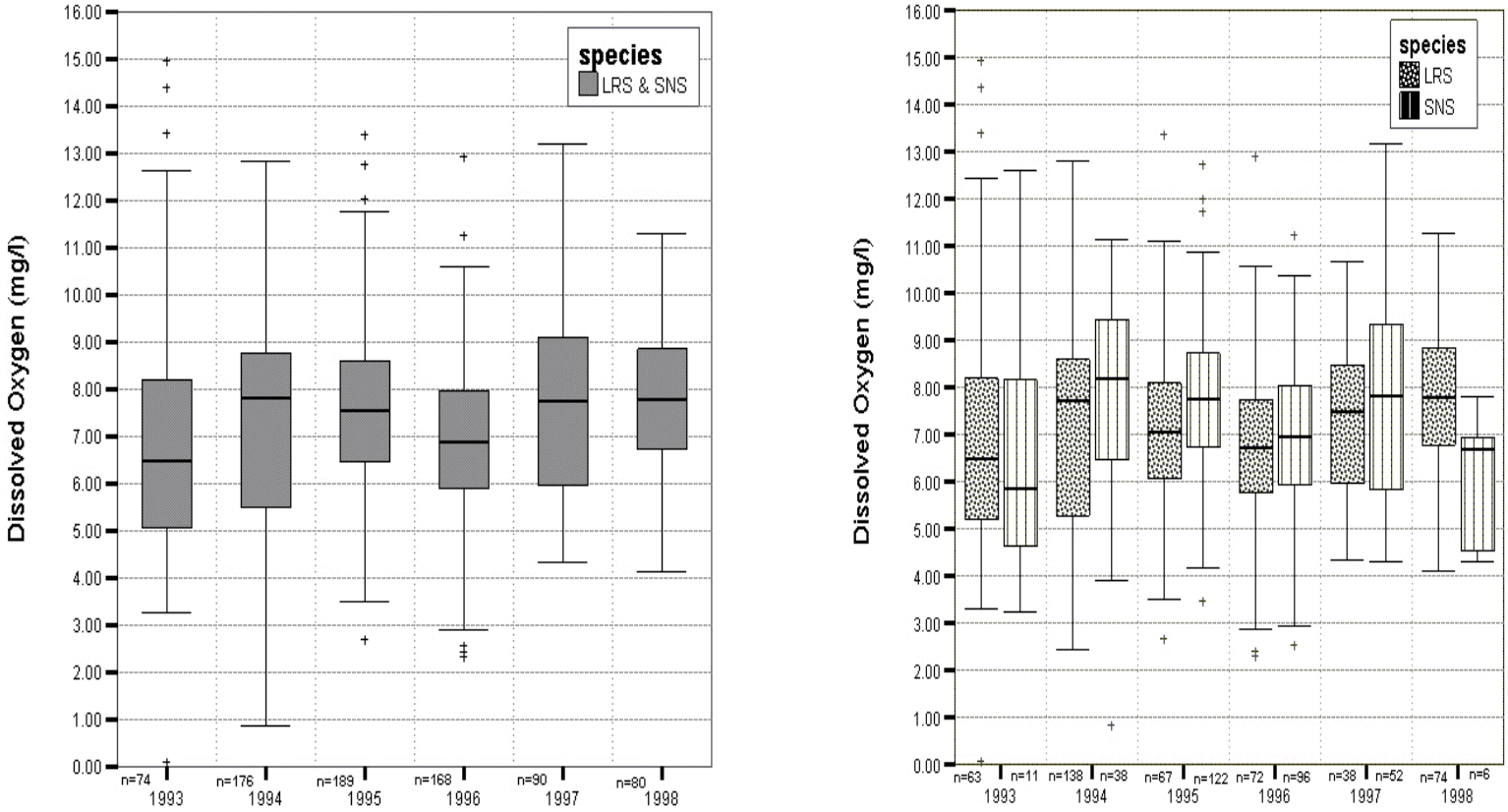


Figure 3. Bottom water dissolved oxygen at sites where radio tagged suckers were located, Upper Klamath and Agency Lakes.

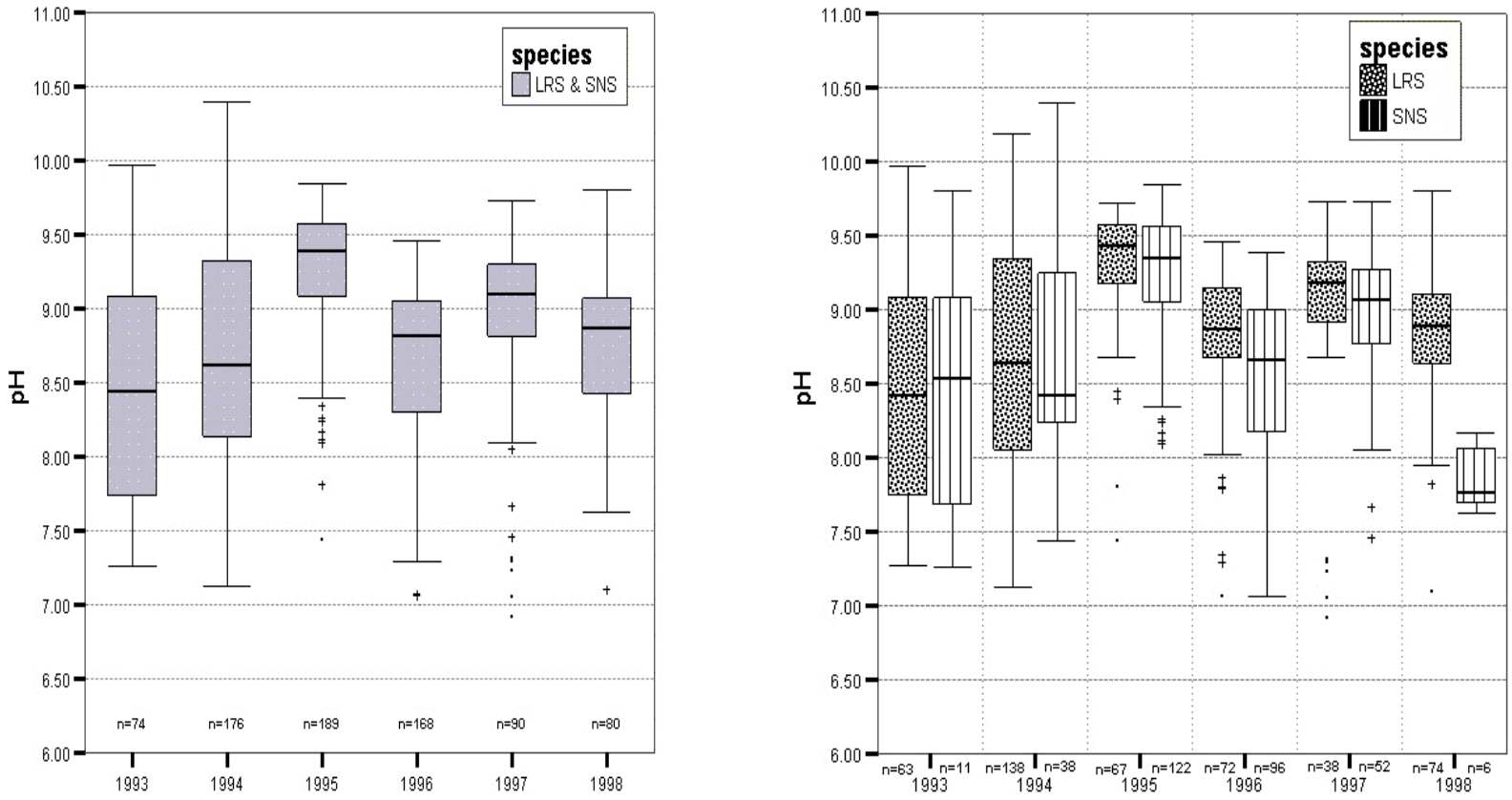


Figure 4. Bottom water pH at sites where radio tagged suckers were located, Upper Klamath and Agency Lakes.

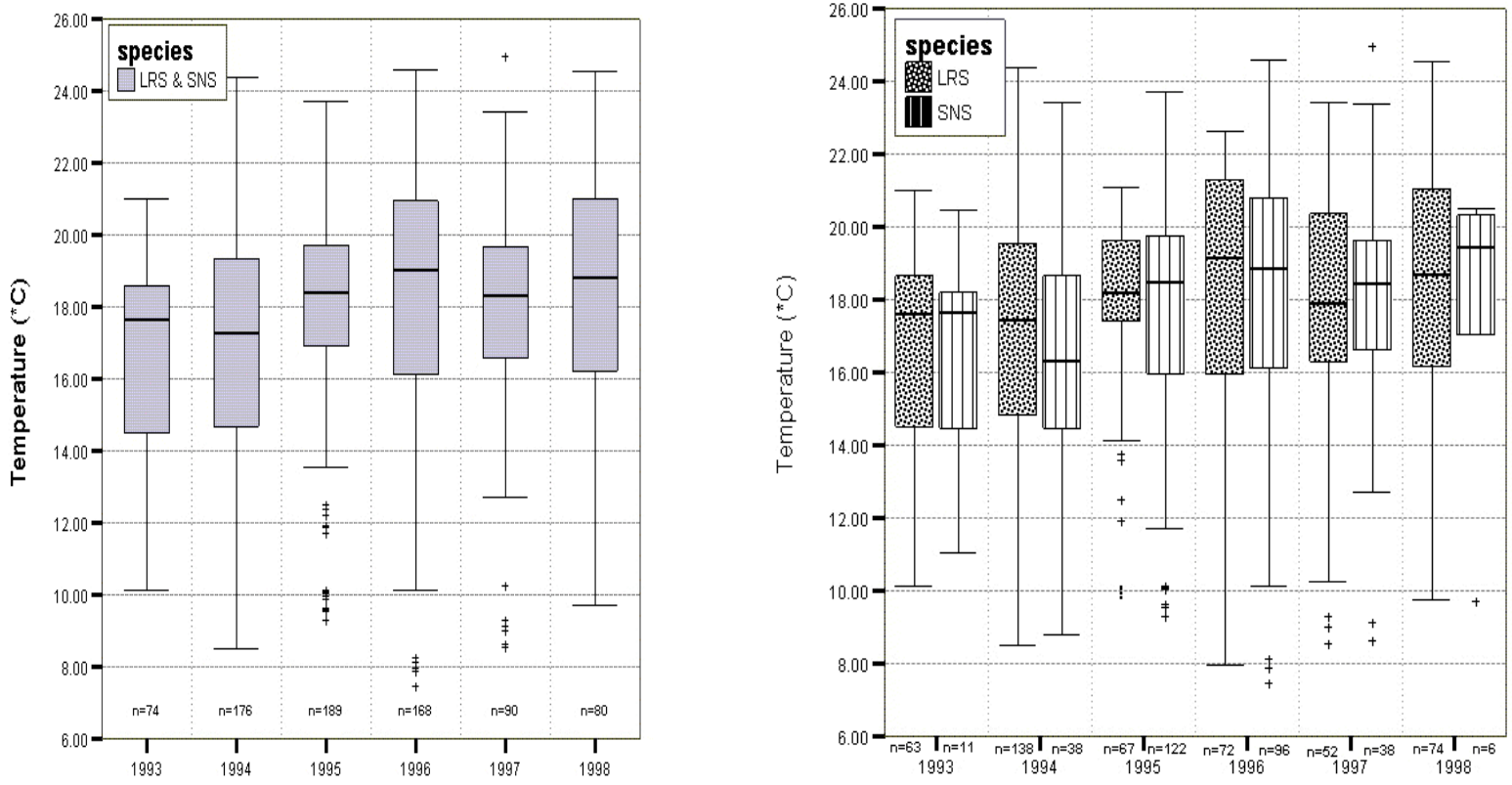


Figure 5. Bottom water temperature at sites where radio tagged suckers were located, Upper Klamath and Agency Lakes.

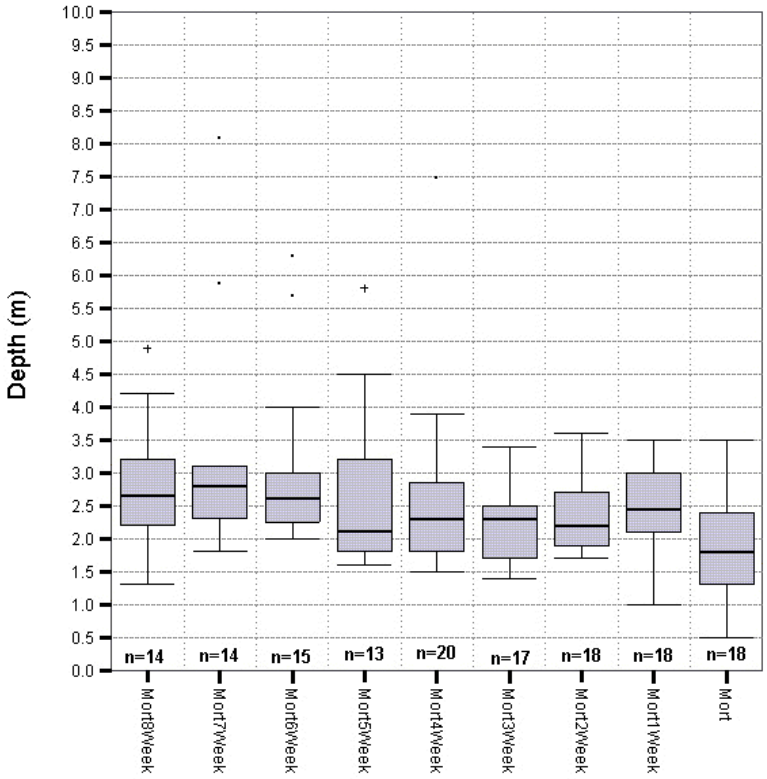


Figure 6. Bottom depth

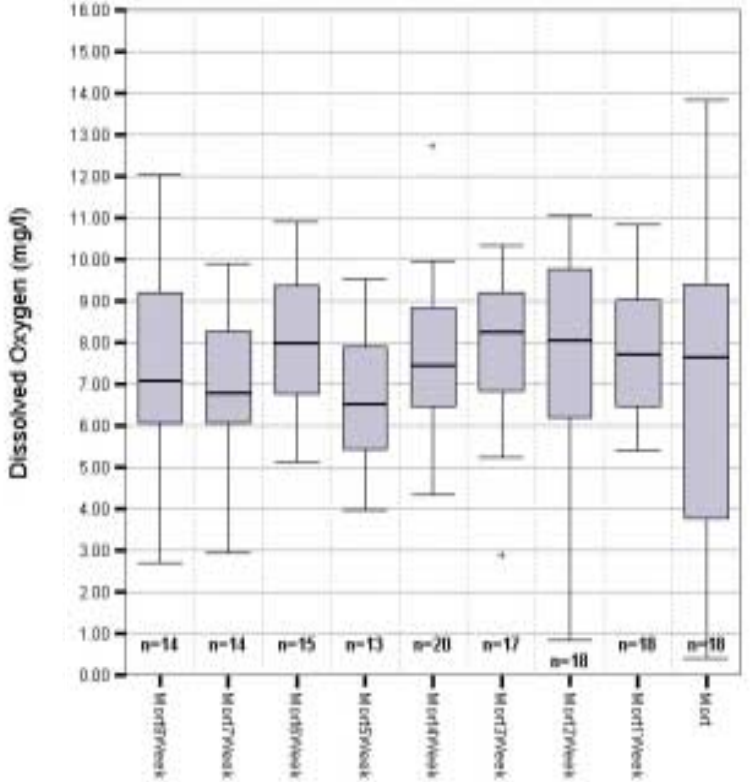
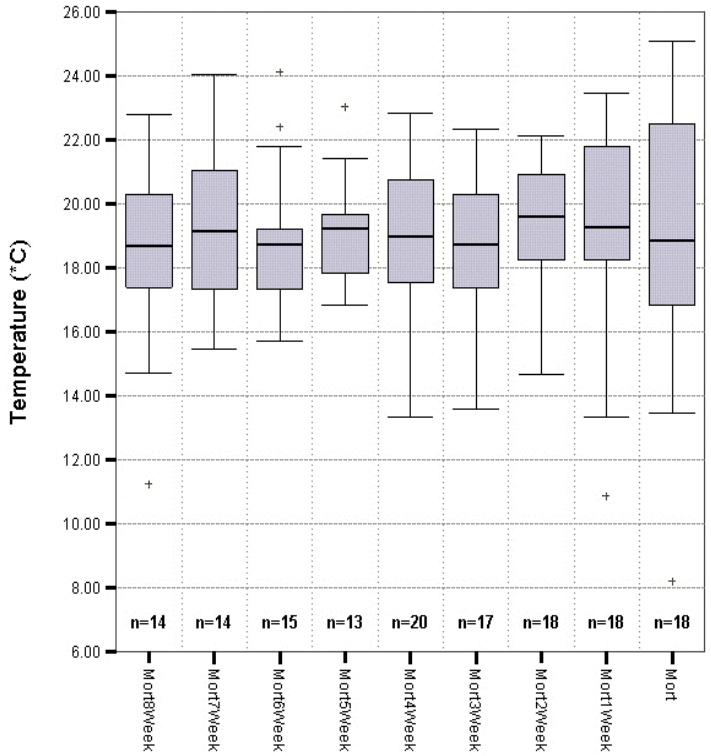


Figure 7. Bottom dissolved oxygen

Bottom water quality at sites where radio tagged shortnose and Lost River suckers were located, Upper Klamath and Agency Lakes. X-axis equals number of weeks prior to all tagged suckers dying, exluding fish that died within one month of tag date (surgery related) or one month from being located in a river (spawning related).



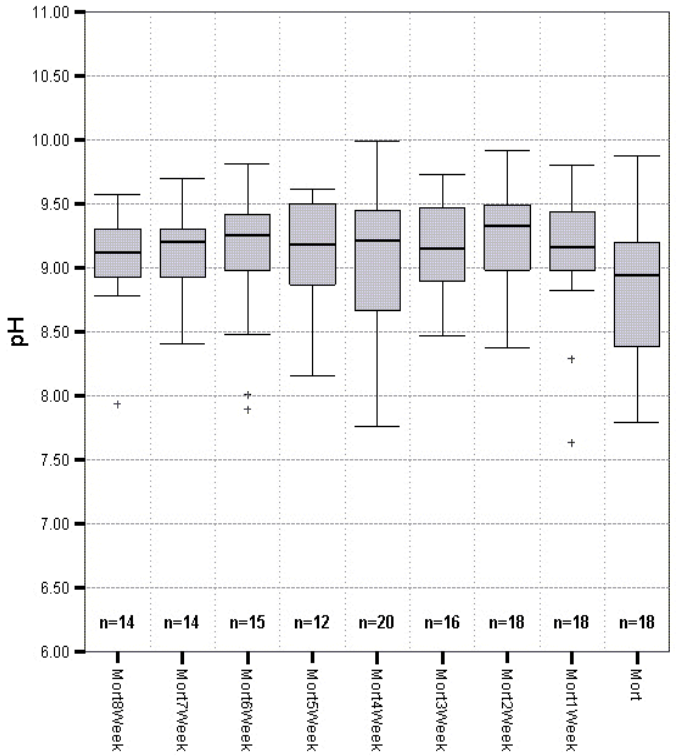


Figure 8. Bottom temperature

Figure 9. Bottom pH

Bottom water quality at sites where radio tagged shortnose and Lost River suckers were located, Upper Klamath and Agency Lakes. X-axis equals number of weeks prior to all tagged suckers dying, excluding fish that died within one month of tag date (surgery related) or one month from being located in a river (spawning related).